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USE OF INSECT REPELLENTS

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More than nine thousand chemicals have been tested as repellents for mosquitoes and other biting flies, chiggers, fleas, and ticks, but only a few of them have proved effective and also safe for general application to the skin or clothing. Some of the effective materials have little or no odor, and give almost complete protection for 2 to 8 hours as skin repellents and for several days as clothing repellents, even in areas where insect populations are high. This publication gives information on their availability, use, and effectiveness. Although they were developed primarily for military use, they are also suitable for civilians. Most of them are on the market in bottles and pressurized containers.

Most Effective Repellents

Diethyltoluamide has proved to be the most outstanding all-purpose individual repellent yet developed. It is effective and safe for general use on the skin and clothing against a variety of biting insects, ticks, and mites. The chemical was synthesized by chemists of the Entomology Research Division. The technical material may contain various amounts of the ortho, meta, and para isomers. Since the meta isomer is the most effective, it should constitute at least 70 percent of the technical product.

Ethyl hexanediol, dimethyl phthalate, dimethyl carbate, and Indalone are also highly effective and are safe for general use on the skin or clothing. Each of these chemicals is outstanding against certain species of insects, but varies in its effectiveness on different persons. The following mixtures have been found effective against a wider range of

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species, under more widely divergent conditions, than the individual ingredient (figures in parts by weight):

Formula 1 (M-2020)

Dimethyl phthalate	4
Dimethyl carbate	3
Ethyl hexanediol	3

Formula 2 (M-250)

Dimethyl phthalate	3
Indalone	1
Ethyl hexanediol	1

Formula 3

Dimethyl phthalate	2
Ethyl hexanediol	1

Formula 4

Dimethyl phthalate	2
Dimethyl carbate	1

Effect on the Skin

Toxicologists have conducted extensive tests with these repellents and have found them safe for use as skin applications. They can be toxic if taken internally. Occasionally there are people who are allergic to certain of the materials that have passed toxicological tests. Such persons may show a slight rash or other minor skin reactions. Any of the repellents may cause some smarting when applied to the mucous membranes or to areas where the skin is especially tender such as the eyelids. Sometimes the treated skin will at first feel warm, especially if it is moist with sweat, but usually the sensation lasts only a few minutes. Repellents cause a severe but temporary stinging if they get into the eyes, and therefore should not be applied too liberally on the forehead. A 50-percent solution of diethyltoluamide in alcohol is the most acceptable cosmetically, having little or no greasy feeling on the skin.

Effect on Paints, Plastics, and Other Synthetic Materials

All these repellents affect paints, varnishes, and many of the plastics to varying degrees. They must be used with caution, as they will damage some types of synthetic cloth (rayon but not nylon), fingernail polish, and articles that are painted or varnished or made of plastic, especially plastic watch crystals. They will not damage cotton or wool cloth if it contains no synthetic fibers.

Ethylene hexanediol and diethyltoluamide are much less injurious to painted surfaces than the other repellents, and usually cause no appreciable injury to plastics. For this reason many persons prefer to use these materials alone rather than one of the mixtures.

Use Against Mosquitoes and Biting Flies

A repellent must be uniformly distributed over the area to be protected, for the insects will discover and bite in any small area that is not covered.

Application to skin.--The most common method of using a repellent is to shake a few drops from the bottle or spray from the pressurized can into the palms, smear evenly, and then apply thoroughly to the backs of the hands, wrists, neck, ears, face, or any other exposed skin, much as in washing. Sufficient repellent should be applied to give a uniform film.

All these repellents except 50-percent solutions of diethyltoluamide in alcohol feel oily to the skin, and may therefore be objectionable to some individuals. However, the protection they afford from biting insects more than compensates for this oiliness. Under favorable conditions one treatment will last several hours on most people. Applications should be repeated when the insects resume biting.



Applying repellent to the skin



Applying repellent to the clothing

Application to clothing.--Clothing properly treated with any of the repellents will give protection for several days. The repellent can be sprayed or daubed on the clothing in areas where the bites occur, such as across the shoulders and along the thighs. One soaking with water, however, removes enough of the repellent to make the treated area ineffective. (See Effect on Paints, Plastics, and Other Synthetic Materials.)

A simple method of applying a repellent to clothing is to shake about a dozen drops into one hand, rub the hands together, and rub lightly on socks, shirt, or trousers where bites occur. Repeat this procedure until the areas to be treated have been covered. If you prefer, apply a light spray to the areas of clothing where the insects are biting.

Shirts, stockings, or other garments may be impregnated with a solution or emulsion of a repellent, as described for use against chiggers. Treated garments will remain effective through 2 to 3 days of ordinary wear, but not after washing or prolonged soaking in water.

Butyl ethyl propanediol is the most effective repellent for treatment of clothing. It should not be applied to the skin. This compound is a solid at normal temperatures and is best applied by the impregnation method in a solution.

Use Against Chiggers

For protection against chiggers (red bugs) the materials should be applied to clothing rather than to the skin, as they act as toxicants rather than as repellents. Treated clothing will be effective for several weeks unless washed or soaked in water. Benzyl benzoate will also protect against chiggers, and clothing treated with it will remain effective after two launderings. Benzyl benzoate may be injurious at high dosages; the recommended dosage should not be exceeded, and it should not be used on the skin (see Impregnation method).

The simplest way to treat your own clothing is to apply a spray as for protection against mosquitoes. If you have a bottled repellent, pour about a dozen drops into one hand, rub the hands together, and then rub lightly on the socks and other clothing. Make liberal applications along all openings of the clothing, such as inside the neck band, and the fly and cuffs of trousers and tops of socks. Do not apply benzyl benzoate by this method.

Impregnation method.--The best method of obtaining complete protection under all conditions of exposure is to impregnate all the outer clothing that will be worn in the field with a solution or emulsion of the repellent. Use about 1/15 ounce per square foot of cloth, or a total of 2 1/2 ounces (5 tablespoonfuls) to a jacket (or shirt), trousers, and socks of medium size. Do not treat the underwear. Benzyl benzoate is preferable for this purpose, as it is more resistant to leaching by water.

Dissolve the repellent in enough dry-cleaning fluid to wet the garment thoroughly but not leave any excess, about 3 pints for an outfit of heavy cotton cloth. After all parts of the garment have been saturated with the solution, allow the cleaning fluid to evaporate.

An emulsion can be made by mixing 2 1/2 ounces (5 tablespoonfuls) of the repellent with 3 pints of water and 1/4 ounce (1 1/2 teaspoonfuls) of an emulsifier or 1 ounce (2 tablespoonfuls) of soap. Suitable emulsifiers are Stearate 61-C-2280 (a polyalkylene glycol stearate); Tween 80 (sorbitan monooleate, polyalkylene derivative); and a polymerized glycol monostearate, monooleate, or monolaurate. Many synthetic household detergents are not suitable for making emulsions, but most laundry soaps are satisfactory. Dissolve the emulsifier or soap in the water and add the repellent slowly while stirring vigorously. If large quantities of clothing are to be treated, a stock solution containing 90 percent of the repellent and 10 percent of emulsifier can be prepared, and added to water as needed, at the rate of 1/2 pint to 1 gallon. Saturate all parts of the garments with the emulsion, wring lightly, and DRY THOROUGHLY before wearing.



Applying a barrier for protection
against chiggers

only the socks above the shoe tops and the bottom of the trouser legs.

Barrier method.-- Considerable protection will be obtained by treating only the openings of the clothes-- inside the neck band, fly, and cuffs of shirts; inside the waist band, fly, and cuffs of trousers; and on the socks, both above the shoes and inside, below the tongue. Apply the material by daubing, spraying, or drawing the mouth of the bottle along the cloth to make a band $1/2$ inch wide. Women's clothing may be protected in the same general way.

If you are not going to be sitting or lying on the ground, you can obtain nearly complete protection by treating

Use Against Fleas

Diethyltoluamide is a superior flea repellent, particularly when used to impregnate socks and outer garments as described for use against chiggers. Clothing impregnated with diethyltoluamide repels fleas for more than a week. Good temporary protection can be obtained by smearing or spraying the repellent on the socks and legs of trousers. Undecylenic (or undecenoic) acid, N-propylacetanilide, and benzyl benzoate are also good flea repellents; clothing treated with them remains effective through several days of ordinary wear.

Use Against Ticks

None of the repellents mentioned above will provide complete protection against ticks, but several will afford a high degree of protection against the most abundant species, the lone star tick. Treat the socks and all the outer clothing by spraying or the impregnation method described for use against chiggers. The best repellents for use against ticks, in order of preference, are Indalone, diethyltoluamide, dimethyl carbate, dimethyl phthalate, and benzyl benzoate. Undecylenic (or undecenoic) acid is more effective but has a rather disagreeable odor. N-Propylacetanilide and N-isopropylacetanilide are the most effective, but are not widely available commercially and are expensive. They are solids and can be applied most conveniently in solution. Treated clothing remains effective against ticks through several days of ordinary wear, but not through washing.



Applying a spray for protection against fleas and ticks

Sources of Materials

These materials may be obtained from the companies listed below. This list does not include all firms, and no discrimination is intended or implied for names omitted, nor is warranty given as to the grade or standard of the product.

Individual Repellents

Benzyl benzoate and dimethyl phthalate

Practically any large chemical firm or your local druggist.

Butyl ethyl propanediol and ethyl hexanediol

Union Carbide Chemicals Co., Agricultural Chemicals Division,
30 E. 42nd St., New York 17, N. Y.

Diethyltoluamide

Cowles Chemical Co., 7016 Euclid Ave., Cleveland, Ohio

Hercules Powder Co., Agricultural Chemicals Division,
984 Market St., Wilmington 99, Del.

Montrose Chemical Co., 120 Lister Ave., Newark 5, N. J.

Dimethyl carbate

Fairfield Chemical Division, Food Machinery and Chemical
Corp., P. O. Box 1616, Baltimore 3, Md.

Sowa Chemical Co., 305 E. 46th St., New York 17, N. Y.

Indalone

Fairfield Chemical Division, Food Machinery and Chemical
Corp.

Kilgore Chemicals, Inc., 812 N. Fairfax, Alexandria, Va.

N-Propylacetanilide, N-isopropylacetanilide, and undecylenic
(or undecenoic) acid

Eastman Organic Chemicals Dept., Distillation Products
Industries, Rochester 3, N. Y.

Commercial Mixtures

Fairfield Chemical Division, Food Machinery and Chemical
Corp.

J. B. Williams Co., 420 Lexington Ave., New York, N. Y.

Union Carbide Chemicals Co., Agricultural Chemical Division

Emulsifiers

Polymerized glycol monolaurate, monostearate, and monooleate
Glyco Products Co., 26 Court St., Brooklyn, N. Y.

Stearate 61-C-2280

Union Carbide Chemicals Co., Agricultural Chemicals Division

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Atlas Powder Co., 9th and Market Sts., Wilmington, Del.

